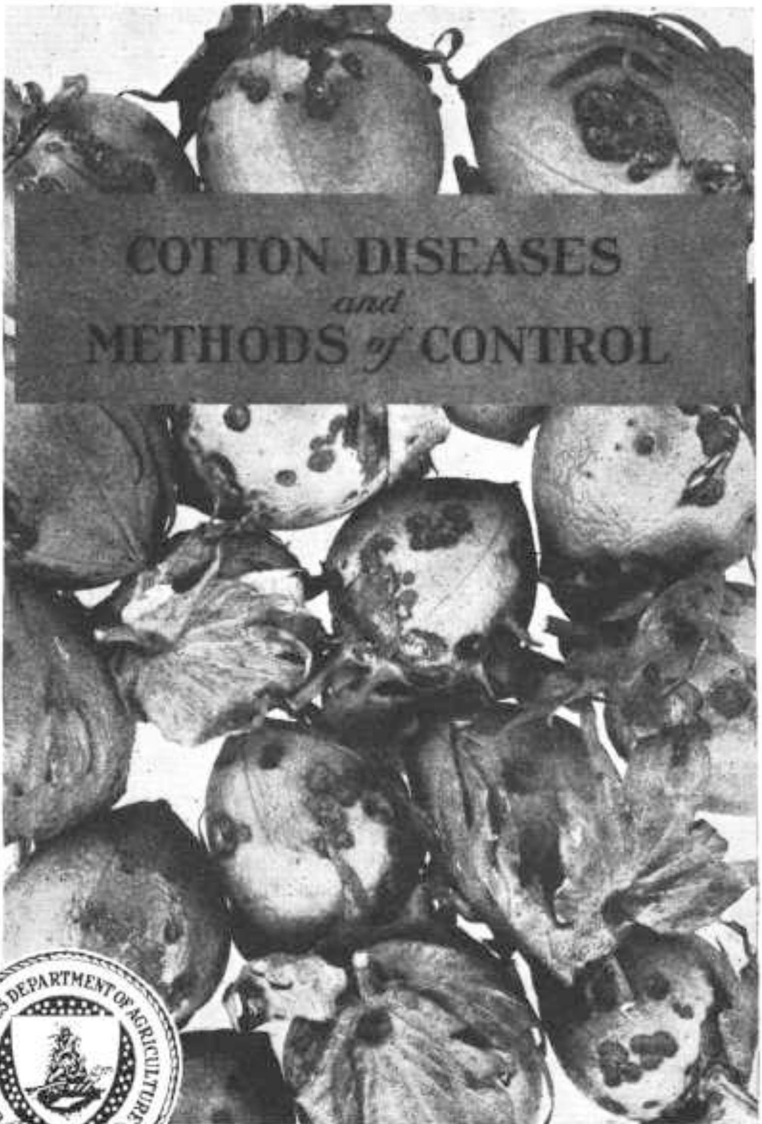
Rev Nov '54

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1745



COTTON DISEASES and METHODS of CONTROL

SUMMARY OF CONTROL MEASURES FOR THE MORE IMPORTANT COTTON DISEASES

Disease	Control measures
Root rot	Rotate with grain crops and subsoil land after grains are harvested. Apply organic manures in irrigated districts. Disinfect isolated centers of infection with ammonia or formaldehyde solution, or ammonium compounds. Construct barriers to prevent spread.
Fusarium wilt	Use wilt-resistant varieties. Fertilize to produce more vigorous plants. Add humus to soil. Rotate to reduce root knot.
Verticillium wilt	Rotate with alfalfa or grain crops.
Root knot	Rotate with immune crops. In irrigated valleys of the Southwestern States maintain clean fallow with deep summer tillage.
Anthracnose	Avoid susceptible varieties. Select seed from disease-free plants or use seed from areas least affected by disease. Rotate crops.
Bacterial blight	Use disease-free seed. Treat seed with organic-mercury dust disinfectants.
Rust	Add humus to the soil. Use potash fertilizers. Drain wet land.
Crazy top	Rotate with alfalfa.

This bulletin is a revision of and supersedes Farmers' Bulletin 1187, Cotton Diseases and Their Control.

Washington, D. C. Issued May 1935

COTTON DISEASES AND METHODS OF CONTROL

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IMPORTANCE OF COTTON DISEASES

COTTON is the most important crop in the Southern States, and within recent years a considerable expansion of the industry has occurred in the irrigated and semiarid sections of the Southwest. In most of the cotton-growing area of the United States the crop is frequently attacked by plant diseases, some of which cause serious losses.

Estimates of the Plant Disease Survey of the Bureau of Plant Industry indicate a loss to the cotton crop from plant diseases in 1932 of 1,687,000 bales. Several of the cotton-producing States were not considered in these estimates, however, and from observations the writers believe that the loss from this cause actually exceeds 2,000,000 bales annually.

The major diseases of cotton are described and illustrated and the best known methods of control are discussed in this bulletin.

ROOT ROT

Root rot is the most important and the most destructive cotton disease in the United States. It is confined largely to the highly calcareous and alkaline soils of the Southwestern States. The region of greatest damage is in Texas in the heavy, black, waxy soil areas. In that State the disease is known to occur in 196 counties. It also occurs in Oklahoma and Arkansas in a few counties adjacent to Texas, and in some of the irrigated valleys of New Mexico, Arizona, and southern

California. The disease also is reported as causing serious damage to alfalfa in Washington County, Utah. The annual losses from root rot run into millions of dollars, and in Texas alone the annual damage to cotton is estimated to be between 10 and 15 percent of the crop. Including the damage to the many other kinds of plants that are attacked by root rot, it has been estimated that the total annual loss caused by this disease in Texas is about $100,000,000.

The root-rot fungus is apparently native, as it is often found on wild plants remote from cultivation, and it frequently attacks cotton and alfalfa when planted on newly cleared land.

SYMPTOMS

Root rot usually appears in cotton fields about the latter part of June or early in July, though in some localities, as in the Rio Grande Valley of Texas, where the crop is planted as a rule in February, it is not unusual to find well-defined spots of infection during May. The first symptom of the disease is a slight yellowing or bronzing of the foliage, followed by the sudden wilting and death of the plant (fig. 1). Neighboring plants are soon attacked, and this continues throughout the season, the rapidity of spread being somewhat dependent on moisture conditions. During warm periods immediately following rainy weather, outbreaks are especially noticeable, and by late summer or early fall many brown spots or irregular patches of dead plants (fig. 2) may be observed. Root-rot affected areas, particularly in the black-land sections of Texas, assume a reddish-brown to black color because of the dead plants, and present a striking contrast to adjoining green, healthy plants.

CAUSE

The root rot of cotton and many other plants is caused by a fungus (*Phymatotrichum omnivorum*) which lives in the soil and attacks and destroys the roots. Although the fungus is found almost entirely in alkaline as distinguished from acid soils, the actual cause of the disease is not an accumulation of so-called "alkali salts" in the soil, as so many cotton growers believe, but the fungus, which attacks the roots. If the roots of freshly wilted plants are examined, a whitish growth is found on the surface, and frequently wartlike wefts occur at the lenticels (fig. 3). In the case of plants that have been wilted for some time, the growth of the causal fungus on the roots is buff to yellowish brown and shows a development of coarse brown strands (fig. 4).

The points of invasion of the root system by the fungus usually are located on the taproot a few inches below the surface of the ground. The infected areas on the roots are depressed, bronze to dark brown in color, and are separated from the healthy tissue by a reddish-brown border. As growth of the fungus proceeds, the infection spreads and rapidly envelops the greater portion of the root system. On roots infected for some time the bark is so shrunken and soft that it slips easily from the wood. When the roots become seriously injured absorption of water from the soil becomes so diminished that the plant cannot replace that lost by transpiration from the leaves, and it wilts. It is not unusual, however, to find the

FIGURE 1.—A cotton plant infected with root rot, showing the characteristic sudden wilting.

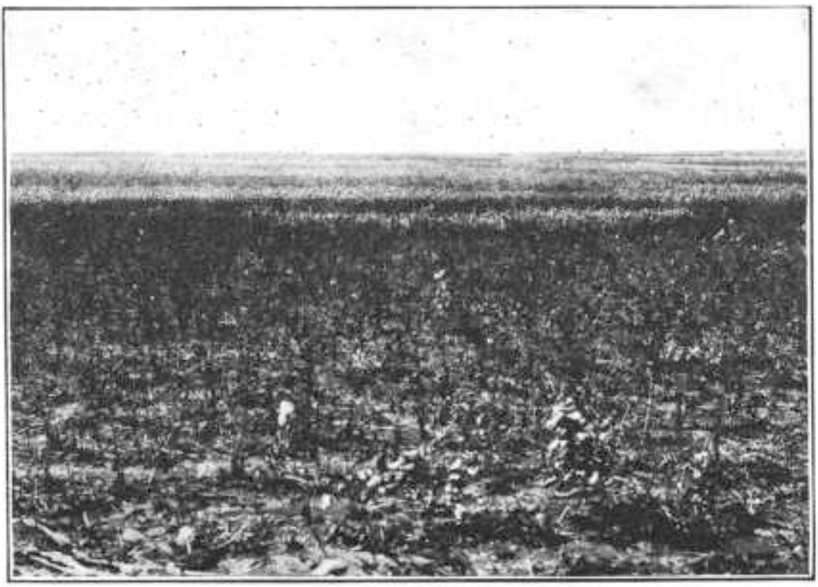

FIGURE 2.—Appearance of root-rot spots in a cotton field late in the season, showing irregular patches of blackened and dead plants surrounded by living green ones.

taproot almost completely rotted away, yet with no aboveground symptoms of the disease. In such cases the plants sometimes remain alive for several weeks, or through the entire season, supported by one or two shallow lateral roots which have escaped infection.

PERSISTENCE AND SPREAD

The fungus may live over from one season to another on the roots of infected plants. Recent experiments have shown also that the root-rot fungus has a sclerotium or hold-over stage which constitutes one of the principal means of carrying over the disease organism in the soil. By means of these sclerotia the fungus is able to remain alive for long periods, at least 3 or 4 years, even in the absence of cotton or other susceptible plants. Numerous excavations made in infested plots kept in clean fallow for 3 and 4 years and in others following 2 and 3 years of grain (resistant crops) have yielded viable sclerotia and strands of the fungus which may produce infection. The sclerotia or hold-over bodies vary considerably in size and shape, but usually are round to ovoid, flattened, and range from the size of a mustard seed to that of a kernel of wheat (fig. 5). These structures are white when newly formed but with age turn yellow to reddish brown. They have been found in the soil beneath infected cotton plants at depths ranging from 2 to 30 inches and frequently occur in colonies or "pockets" in chainlike arrangement (fig. 6), especially in the heavy black lands of Texas. Deep-seated infestation in many sections of Texas and Arizona is also common, both sclerotia and coarse strands of the fungus often existing on roots and stumps of trees killed by the disease several years before.

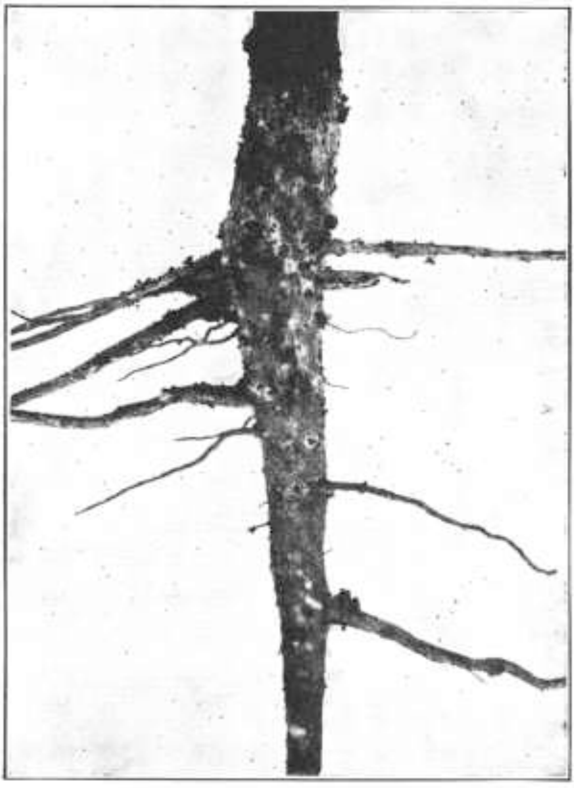

FIGURE 3.—Appearance of roots of a cotton plant infected with root rot. Note wartlike wefts of the fungus at the lenticels.

During favorable seasons, especially in warm periods following rainy weather, the root-rot fungus may spread rapidly in the field, the

infested areas in cotton or alfalfa fields usually enlarging from a center in ever-widening circles. The spots where all the cotton plants have died in one season may break up or disappear in following seasons and later recur independent of any cultural treatment.

Little is known regarding the means of dissemination of the fungus to new locations. Since, however, sclerotia and strands of the fungus as well as infected plant roots may perpetuate the disease, any practice involving soil transfers from infested localities should be carefully avoided, so as not to risk the introduction of the disease into root-rot-free areas. The movement of balled nursery stock or ornamental plants from root-rot areas is restricted in some States by quarantine regulations.

FIGURE 4.—A cotton root showing the well developed coarse brown strand growth of the root-rot fungus. × 11.

OTHER PLANTS AFFECTED

In addition to cotton, more than 600 cultivated and wild plant species are known to be susceptible to root rot. Important cultivated crops attacked by the disease include alfalfa, clovers, peas, beans, peanuts, sweetpotatoes, turnips, carrots, and okra. Many fruit trees, ornamental plants, and shade trees are also affected. Among the trees and shrubs frequently killed by root rot are apples, figs, grapes, plums, elms, chinaberry, mulberry, poplar, sycamore, rosebushes, and privets. Some trees, such as citrus, pecan, hickory, cottonwood, pomegranate, and athel (*Tamarix aphylla*), if not killed in the seedling stage are able to withstand the disease and may live for many years.

CONTROL

ROTATION AND CULTIVATION

Owing to the great diversity and number of plants affected by root rot and the fact that the organism persists in the form of sclerotia and strands, no very satisfactory control measures have as yet been developed. In Texas, where the disease is particularly serious, a 2-year or preferably a 3-year rotation with grain crops, combined with deep tillage immediately after the grain is harvested, has reduced the disease somewhat. Rotation may include corn, wheat, oats, and especially grain sorghums, or other crops that have been found resistant to root rot. As a cultural treatment, liberal

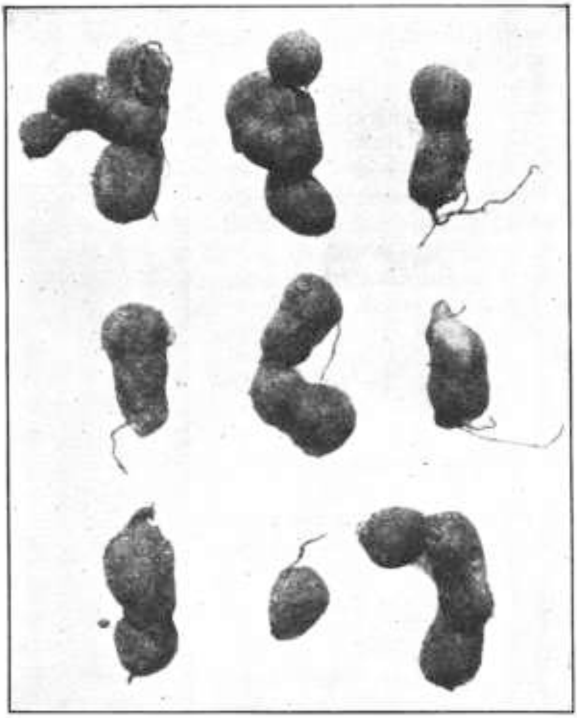

FIGURE 5.—Sclerotia or hold-over bodies of the cotton root-rot fungus. × 6½.

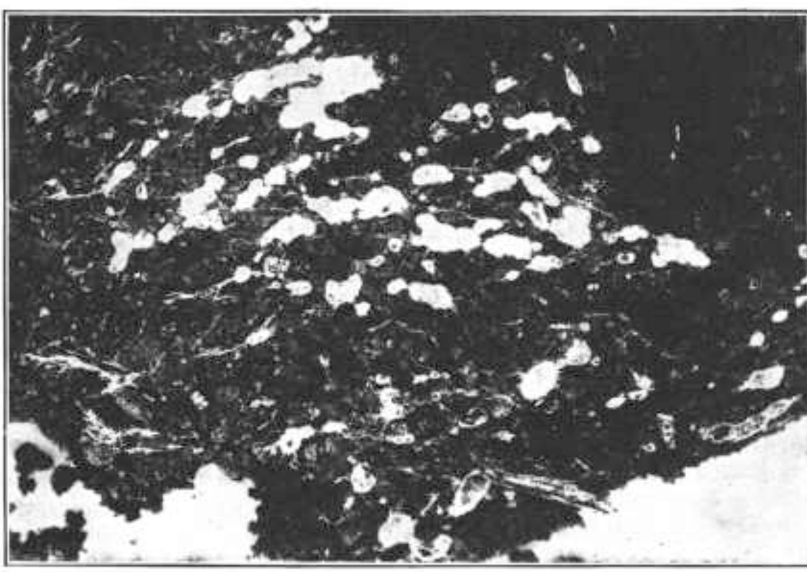

FIGURE 6.—A lump of soil broken open, showing the chainlike arrangement of the sclerotia of the root-rot fungus as they occur in Texas black-land soils. (Nearly natural size.)

applications of organic manures have been effective in some irrigated regions.[1]

The more important plants grown in the area where root rot prevails and their resistance or susceptibility to the disease as determined in tests by the Texas Agricultural Experiment Station are as follows:

Crops highly resistant to root rot

Asparagus	Millet	Sorghum
Barley	Oats	Strawberry
Corn	Onion	Sugarcane
Grasses	Rice	Wheat

Crops partially resistant to root rot

Cabbage	Lettuce	Tobacco
Cauliflower	Muskmelon	Tomato
Collards	Pea, garden	Turnip
Cucumber	Peach	Velvetbean
Guar[2]	Pecan	
Kale	Potato	

Crops most susceptible to root rot

Alfalfa	Cowpea	Privet
Apple	Fig	Rose
Bean	Grape	Soybean
Clover	Peanut	Most vegetables
Cotton	Pear	

Weeds attacked by root rot

Cocklebur	Horsenettle	Ragweed
Groundcherry	Lambsquarters	Tievine

SOIL DISINFECTION

Although many soil disinfectants have been tried in attempts to eradicate root rot, the results in general have not been satisfactory. However, for eradicating small centers of infection in cotton fields or in areas where one desires to make limited plantings of fruit trees, shade trees, or ornamental plants, dilute solutions (2 and 4 percent, respectively) of either formaldehyde or ammonia water[3] may afford protection. Ammonium phosphate or ammonium sulphate plus hydrated lime (3 parts of lime to 5 parts of ammonium sulphate) may also be used in treating small areas of infection, if the work is thoroughly done.

The formaldehyde solution is made by placing 2½ gallons of formaldehyde (40-percent U. S. P.) in a barrel or other wooden container and diluting with water to make 50 gallons. Approximately 4-percent ammonia water is prepared by adding 8 gallons of strong ammonia water (28 percent) to 42 gallons of water. The soil in the diseased area should first be thoroughly worked or spaded to a depth of 12 to 18 inches and then saturated with the ammonia solution at least 6 to 8 months before planting.

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[1] Demonstrate to be a practicable control measure in Arizona.
[2] An East-Indian annual legume introduced into the arid parts of the United States as a forage crop.
[3] Preferable for Texas black-land soils.

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It should be remembered, however, that the effective use of soil disinfectants is restricted to areas where the fungus can be reached by such treatment. In many of the infested districts of Arizona, southern California, and southern Texas the fungus often extends to depths of 4 or 5 feet, and in such cases the use of disinfectants for eradication purposes becomes impracticable.

BARRIERS

Various kinds of barriers to limit the spread of root rot in the field have been developed. Among these are trench barriers containing mixtures of soil and such chemicals as ammonia and sulphur; mixtures of soil and waste motor oil, and open trench barriers of varying depths. One with ammonia may be prepared by digging a trench 10 to 12 inches wide and 1 foot deep, about 4 to 6 feet in front of the zone of infected plants, and saturating this with 6-percent ammonia water [4] at the rate of 1 gallon per lienar foot. The trench is then filled with soil from a root-rot-free area. A similar barrier may be made with waste motor oil. When waste motor oil is used, however, a trench 6 inches wide and about 20 inches deep is advisable, and dry soil is necessary for thorough incorporation of the oil. The two are mixed in the proportion of 1 part of oil to 10 parts of soil by weight. After the trench has been dug to the stated depth the desired barrier width is obtained by using board forms in the trench and filling the space with the oil-soil mixture. The latter is packed down thoroughly and the forms removed after the space on the opposite side has been filled with soil.

The Texas station also has found that 4 to 12 rows of grain sorghum are valuable barriers to prevent the spread of root rot.

FUSARIUM WILT

Fusarium wilt, commonly called black root, from the fact that the diseased roots turn black, and known also as cotton wilt, is a disease occurring in many sections of the Cotton Belt. It is second only to root rot in the amount of loss it causes to the crop. It is especially prevalent on the light sandy soils of the Coastal Plain, extending from Virginia to New Mexico. It is less prevalent on clay or alluvial soils, but it does occur in such areas. It is most common and severe in eastern North Carolina, central and eastern South Carolina, central and southern Georgia and Alabama, Mississippi, Louisiana, eastern Arkansas, Oklahoma, and Texas. Recent surveys show that cotton wilt is on the increase in both the sandy and the heavier upland soils of South Carolina and Mississippi. In most of the States mentioned above it is the most important and destructive cotton disease. It occurs every year, though in some seasons losses are heavier than in others. In occasional severe cases the yield is sometimes reduced as much as 75 to 90 percent. Instances of damage amounting to 25 percent or more are not uncommon wherever the disease is present in the soil to any appreciable extent and nonresistant varieties are grown. The average annual loss due to wilt is estimated to be about 4 or 5 percent.

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[4] Approximately 6-percent ammonia water in 50-gallon lots is prepared by adding 11½ gallons of strong ammonia (28 percent to 38 gallons of water.

SYMPTOMS

Fusarium wilt of cotton usually makes its appearance about the last of June or early July, but occasionally the plants are attacked and killed even in the seedling stage. This disease may be suspected when plants wilt and die without any apparent reason. Early in the season wilt-infected plants appear dwarfed as compared with healthy plants, and the leaves turn yellow at their margins and between the veins. Frequently the main stem of infected plants remains short, while one or more lower branches grow normally (fig. 7). The chief symptoms are premature wilting and the characteristic internal appearance of affected stalks. If the stem of a freshly wilted plant is cut across near the ground and the vascular tissues are brown or black inside, there is strong evidence of the disease. This vascular discoloration may extend up the stalk into the main branches, frequently into the leaf petioles and pedicels, and sometimes into the seeds (fig. 8). Other symptoms of wilt are shorter taproots, fewer lateral roots, and the excessive shedding of leaves, producing bare stalks. Also, in many cases, the upper part of the plant dies.

FIGURE 7.—Cotton plant infected with fusarium wilt. Note stunted appearance and partial defoliation.

CAUSE AND SPREAD

Cotton wilt is caused by a fungus (*Fusarium vasinfectum*), which lives in the soil and infects the plant through the roots. By its growth it produces toxic substances which finally accumulate in sufficient quantity in the plant to cause wilting and death. The wilt fungus is able to live in the soil for several years, so that crop rotation as a control measure is not effective. After the plants are killed the fungus continues to grow within the tissues, eventually rotting the roots, and later, if conditions are favorable, it forms spores (reproductive bodies) in abundance on the roots and infected stems which are left in the soil.

It is generally believed that cotton wilt, like many other wilt diseases of various crops, may be spread from field to field by animals, men, cultivating implements, wind, drainage water, or other agencies

that carry soil particles. Experiments have shown, however, that the disease is not easily conveyed from one field to another by such means. There is also very little evidence that the disease is disseminated in practice to any appreciable extent in or on the seed, although in a few cases this has been done experimentally.

CONTROL

The planting of wilt-resistant varieties of cotton and liberal fertilization to produce more vigorous plants are the most effective methods of controlling wilt. Large applications of potash alone and fairly large applications of potash in combination with nitrogen- and phosphorus - containing salts, according to the Arkansas Agricultural Experiment Station, have reduced cotton wilt at points in central, eastern, and northeastern Arkansas. The Mississippi Agricultural Experiment Station also reports that fertilizers high in nitrates and potassium have uniformly given a smaller amount of infection on inoculated soil. Experiments in both of these States have shown that the amount of wilt and rust is greatly reduced through applications of 600 pounds per acre of 6–8–12 or 6–8–6 (N–P–K)[5] fertilizer. The control of wilt through such fertilizer applications also is usually accompanied by marked increases in yield. Measures that maintain an adequate content of organic matter in the soil and crop rotation are important supplemental factors in decreasing wilt damage. The use of vetch, winter peas, crimson clover, root-knot-resistant varieties of cowpeas, and soybeans as soil-building crops increases production, aids in delaying infection by the wilt fungus, and assists in maintaining the resistance of the cotton plant to wilt and other diseases.

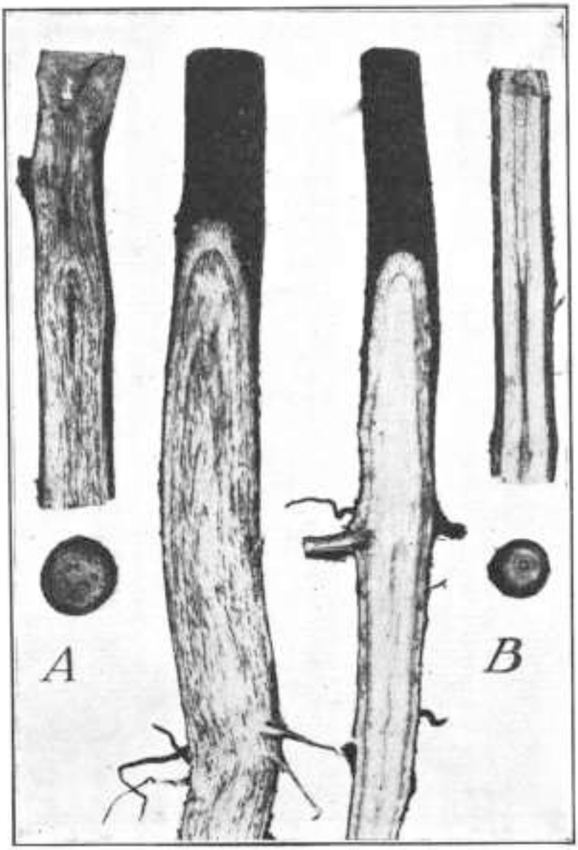

FIGURE 8.—Longitudinal and cross sections of fusarium wilt-infected and healthy cotton stems and roots: *A*, Wilt-infected; *B*, healthy. Note black discoloration of diseased tissues as shown in *A*.

[5] Nitrogen phosphorus potash.

In areas where root knot is prevalent, especially in light sandy soils, wilt is also more prevalent and destructive. In these localities it is necessary to plant root-knot-resistant crops for 1 or more years before attempting to control the wilt even by growing wilt-resistant varieties of cotton.

WILT-RESISTANT VARIETIES

Several wilt-resistant varieties of cotton have been bred by the United States Department of Agriculture, by various State experiment stations, and by a number of cotton breeders. Some of these varieties are planted extensively, and for many years have produced profitable crops on wilt-infested soils. Wilt-susceptible varieties cannot be used successfully on land that is heavily infested with the wilt fungus (fig. 9).

FIGURE 9.—Resistant and susceptible varieties of cotton growing on wilt-infested soil. Note the vigorous growth and healthy appearance of the resistant varieties at the right and left as compared with the scant growth and sickly appearance of the two susceptible varieties in the center.

Among the wilt-resistant, short-staple upland varieties developed by the Department and selected for earliness, productivity, and qual-
more productive, matures earlier, and has a better staple, ranging
ity of fiber are Dixie and Dixie Triumph. Of these, the latter is
from fifteen-sixteenths of an inch in some localities to $1\frac{1}{32}$ inches in others. It is planted extensively in the wilt-infested districts of North Carolina, South Carolina, and Georgia and in parts of Alabama, Louisiana, and Arkansas. A number of other wilt-resistant cottons have been developed in recent years. Among these are Tri-Cook, Cook 307–6, Cleveland 54, Miller 642, Express 121, Dixie 14, Rowden 40, D & P L 6, D & P L 4–8, Coker Lightning Express, Coker Super Seven Strain 5, Clevewilt, Rhyne Cook, Covington-Toole, Council Toole, Lewis 63, and Watson Long Staple. Other resistant strains, some of which have considerable merit for local

conditions, have been developed by individual farmers in various States. Further information concerning these may be obtained from the State experiment stations in the Cotton Belt or from the United States Department of Agriculture.

The breeding of wilt-resistant strains of cotton is a long and tedious operation, requiring in most instances special facilities in the way of uniformly infested land, isolation of seed plots, and special ginning. Because of the expense, it will not pay the average farmer to produce his own wilt-resistant strains. If his land is infested, new seed of a wilt-resistant variety adapted to his locality should be obtained every 2 or 3 years, either from his State experiment station, from a reliable breeder, or from some carefully managed one-variety cotton community.

VERTICILLIUM WILT

Verticillium wilt of cotton, similar in many respects to fusarium wilt, has been known in the United States only since 1927. It is known to occur in Arkansas, California, Mississippi, Oklahoma, Tennessee, and Virginia. The disease is quite prevalent in the Delta counties of Mississippi, in Tennessee and Arkansas, and in the San Joaquin Valley of California. In the Mississippi Delta the infection varies from a trace to as much as 40 percent in some fields.

SYMPTOMS

In the Delta sections of Mississippi and in Tennessee the disease appears about the first week in July, usually following rainy weather, as the plants are approaching maturity. The symptoms of the disease as found in this region agree very closely with descriptions given of this wilt in California.

The first outward symptom is a distinct mottling of the leaves with pale-yellowish irregular areas appearing at the margins and between the principal veins, showing a deficiency of chlorophyll. These symptoms occur in early summer, usually on the lower leaves of the plant, spreading to the middle and upper leaves later in the season. The yellow areas gradually become paler, finally dying and turning brown (fig. 10). At the time or even before the yellow discoloration appears in the leaves, a longitudinal cut into the wood at the base of the main stalk may reveal a slight browning of the vascular system, which later becomes very pronounced. In the late summer, when the effect of the disease is most apparent, the leaves of badly diseased plants present a mosaic pattern of rust-colored dead areas with yellowish margins, lying between narrow strips of green, bordering the principal veins. Later the leaves fall, and the plant may become defoliated except for a few small leaves at the top of the plant and at the ends of the branches.

The leaf symptoms mentioned above, such as mottling and discoloration, although characteristic of this disease, also occur in cotton plants infected with fusarium wilt and hence cannot be used as a distinguishing character for either disease. Discoloration of the vascular tissues of the stems and roots also occurs in both wilts. Although difficult to distinguish from fusarium wilt except by laboratory culture methods, some differences in the two diseases may

be recognized. Plants infected with fusarium wilt are characterized by dwarfing and are frequently killed during the season, whereas those infected with verticillium wilt are not dwarfed, seldom are killed, and often produce yields comparing favorably with normal plants. The development of new slender branches at the base of the plant (fig. 11) also frequently occurs in cotton plants infected with *Verticillium*. The almost complete shedding of leaves during August and September is especially characteristic of cotton plants infected with verticillium wilt (fig. 12), the same symptoms occurring much earlier and to a somewhat less extent in plants infected with fusarium wilt.

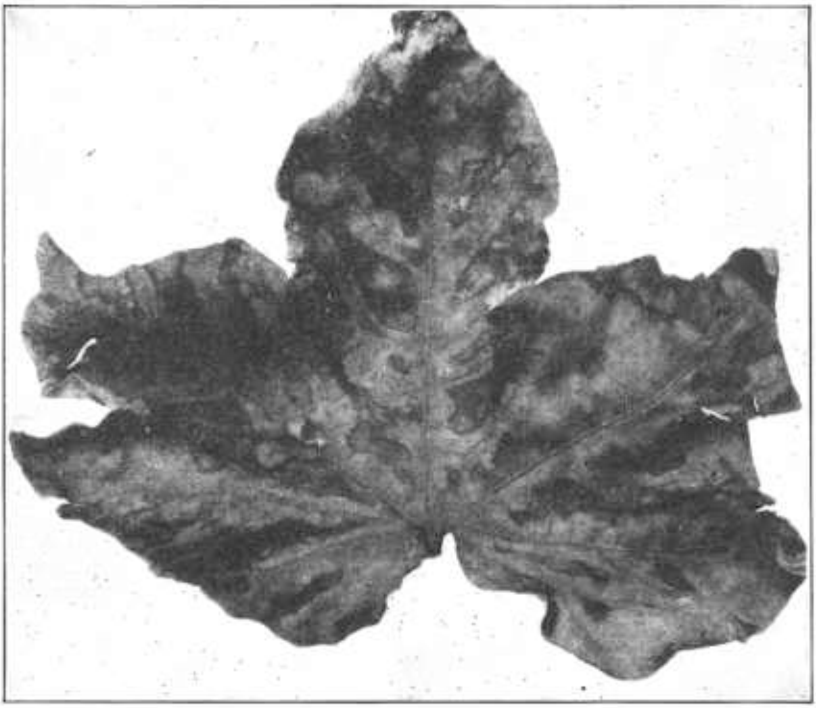

FIGURE 10.—Leaf from cotton plant infected with verticillium wilt. The dead areas are brown, with pale-yellowish margins.

CAUSE

Verticillium wilt is caused by a soil fungus (*Verticillium albo-atrum*) which enters the roots of the cotton plant in the same manner as described for fusarium wilt. It causes wilting, mottling, and shedding of leaves and vascular discoloration of the roots and stems.

The disease attacks many other plants besides cotton, such as potatoes, tomatoes, and deciduous fruit crops. It may have been introduced into certain cotton-growing localities through the planting of some of these crops, especially infected potatoes, which are grown extensively in areas where the disease has been known to occur for several years. The appearance of the disease in cotton communities in which other susceptible crops have not been grown previously to

any considerable extent would indicate, however, that there are other sources of infection. Perhaps the fungus may be transferred by flood waters from *Verticillium*-infested districts or by other agencies that carry infested soil.

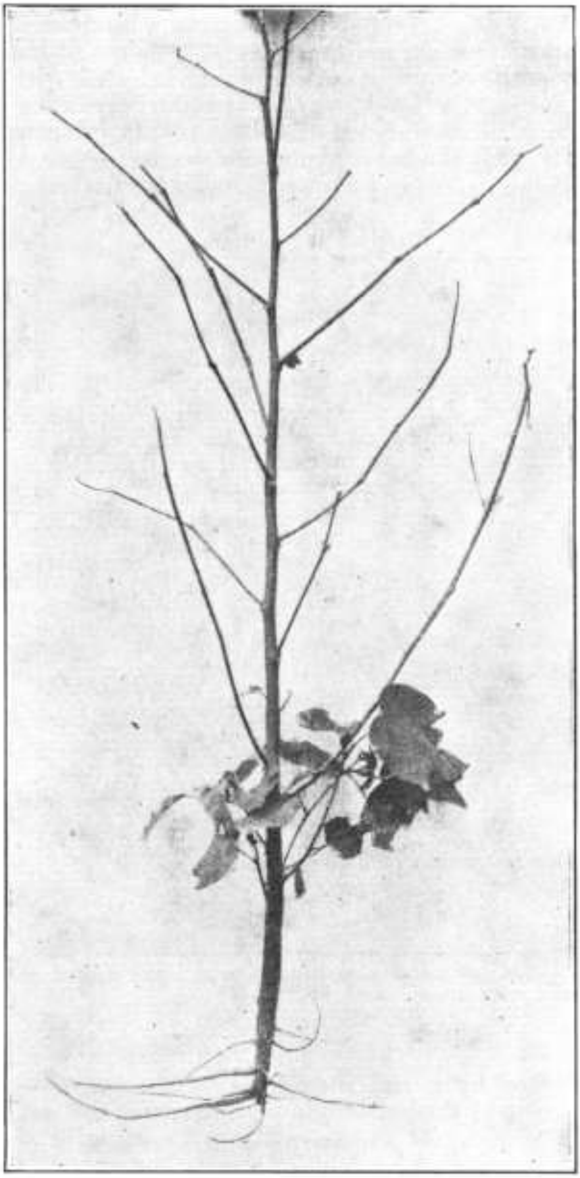

FIGURE 11.—A cotton plant infected with verticillium wilt, showing the development of new slender branches at the base of the stalk. This is a distinctive feature of the disease in the Mississippi Valley.

There is as yet no evidence that the disease is disseminated in the seed. Seed collected from infected plants in the Mississippi Delta and in California in 1929 and planted on disease-free soil the following season produced healthy plants.

CONTROL

No definite control measures for verticillium wilt are known. Rotation with alfalfa or grain crops is suggested as a possible means of reducing infection in cotton fields. Breeding resistant varieties of cotton may solve the problem.

ROOT KNOT

Root knot affects the cotton crop more or less in practically every State in the Cotton Belt. Like wilt, it is most severe on sandy soils of poor water-holding capacity. The disease is widely prevalent in the Coastal Plain and the sand-hill and light-soil areas of Florida, Georgia, Alabama, North Carolina, South Carolina, Mississippi, Louisiana, Arkansas, and Texas. It occurs also in southern California and in Arizona. The

Plant Disease Survey of the Bureau of Plant Industry estimates a loss to the cotton crop from root knot varying from a trace to as much as 4 percent annually in some States. Losses in exceptional cases may amount to 80 percent. The average losses for all sandy lands in a single county in South Carolina were estimated at 4.4 percent in 1917, and in 1932 the loss for the State of North Carolina was estimated at 5 percent.

Every cotton farmer should realize that the damage caused by root knot is not confined to direct injury to the cotton plant. Root-knot-diseased plants are also much more subject to wilt, and the two diseases occur very commonly together. For this reason cotton wilt is much worse following root-knot-susceptible cowpeas or other crops that increase the causal agent in the soil. Loss from root knot also is increased (1) by the greater cost of cultivating infested land due

FIGURE 12.—Cotton plants growing in Washington County, Miss., showing almost complete defoliation as a result of verticillium wilt infection. (Photographed in October.)

to weed growth where the cotton has died, (2) by lowering the market value of such land, and (3) by the fact that badly diseased land must often be used for crops less profitable than cotton. Many other farm crops are also susceptible to this trouble.

SYMPTOMS

Plants affected with root knot are usually dwarfed or stunted, and the leaves and stems are pale yellowish green. Deformities, such as irregular branching and the dying back of the main stalk, which characterize plants infected with fusarium wilt (fig. 7) are not usual in plants affected with root knot. In mild cases of the disease even the dwarfing and abnormal color of the leaves may not be especially noticeable. Severe attacks, however, may kill practically all the plants in the field. During hot, dry weather affected plants tend to

wilt more than normal ones. The pest affects all susceptible crops alike, causing swellings, galls, and discolorations of the roots, which stunt the growth of the plants by cutting off the food and water supply. The disease can be identified by examining the affected roots. If they show numerous more or less irregular knots or swellings, ranging from the size of a pinhead to one-half inch or more in diameter (fig. 13), root knot may be suspected. The knots or galls occur on both the feeding rootlets and the taproot, depending on the severity of the attack. When young, they are white; but with age they turn brown and decay. Root knot is especially severe on Egyptian cotton when planted on areas infested with the causal agent. In Arizona seedling stands frequently are greatly reduced by root-knot injuries, which growers usually attribute to sore shin.

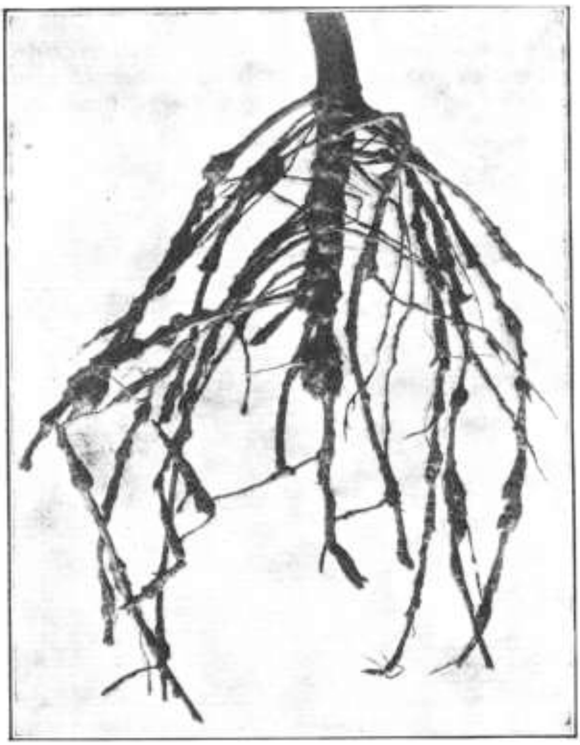

FIGURE 13.—Root system of a cotton plant severely attacked by root knot.

CAUSE AND SPREAD

Root knot of cotton and other crops is caused by minute eelworms or nematodes (*Heterodera marioni* (*Caconema radicicola*)) which bore into the roots from the soil. They multiply inside the root tissue, living at the expense of the plants and causing them to form galls or swellings on the roots. If the interior of the knots is examined, small, pearly white, rounded bodies about the size of a mustard seed may be seen. These are the female nematodes (fig. 14, *A*). The male worms can be seen only with the microscope or hand lens. They are very slender and narrowed toward either extremity (fig. 14, *B*).

The root-knot organism may spread from field to field in various ways. It may be transmitted by drainage water, irrigation water, agricultural implements, cultivation, soil clinging to the feet of animals or men, or by any means that carry infested soil or plant roots. The introduction of the disease into new localities is often accomplished by means of infested nursery stock, tubers, bulbs, and seedlings. Young peach trees, figs, grapevines, cabbage, tomato, and strawberry plants, or other plants grown in infested soil, as well as

infested potatoes and sweetpotatoes used for seed purposes, are frequently responsible for the dissemination of root knot.

CONTROL [6]

Rotation with nonsusceptible crops, so as to starve out the nematodes in infested fields, is the most effective and practicable means of controlling root knot. In fields where the disease is severe, winter grains, resistant summer legumes, or other resistant crops should be grown for at least 2 or 3 years in succession before the land is returned to cotton. Such a rotation consistently followed gives fair control, whereas the continuous planting of cotton on infested land or following other susceptible crops will almost invariably result in heavy losses. In the irrigated valleys of the Southwestern States root knot of field crops can be eradicated by clean fallow with deep summer tillage in about 3 years.

A list of cultivated plants, including both field and truck crops, which are resistant or susceptible to root knot is given below. From these, suitable rotations may be devised for most localities.

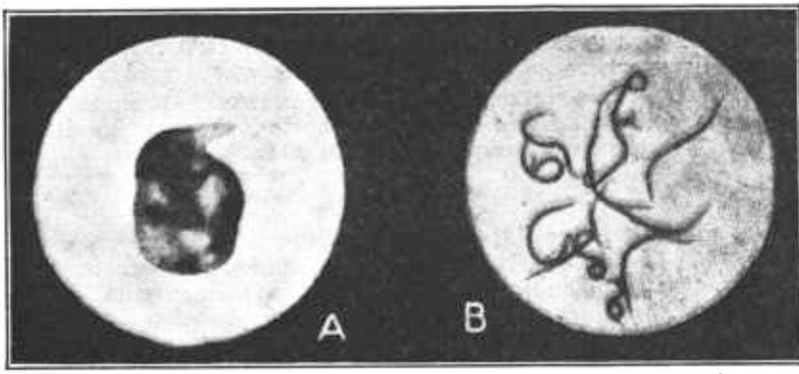

FIGURE 14.—The nematodes that cause root knot: *A*, Adult female full of eggs (× about 24); *B*, larval specimens (× about 60).

Crops largely or entirely immune to root knot

Barley
Beggarweed, Florida
Chufa
Corn
Cowpea (Brabham, Iron, Victor)
Crotalaria spectabilis
Grasses (nearly all, including Bermuda grass and crabgrass)
Kafir
Millets (nearly all)
Milo
Oats, winter
Peanut
Rye
Sorghum
Soybean (Laredo variety only)
Velvetbean
Wheat

Crops not very severely affected by root knot

Alfalfa
Asparagus
Bean, snap
Cabbage
Collards
Cotton
Pea, garden
Radish
Soybean (Otootan)
Spinach
Strawberry
Sugarcane
Sweetclover
Sweetpotato
Vetch, common

[6] More detailed information on root knot and its control is given in Farmers' Bulletin 1345, Root-Knot, Its Cause and Control. This publication may be purchased for 5 cents from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Crops most severely affected by root knot

Bean, lima
Beet
Bur-clover
Carrot
Celery
Cowpea (all varieties except Iron, Brabham, and Victor)
Cucumber
Eggplant
Fig
Lettuce
Muskmelon
Okra
Peach
Potato
Salsify
Soybean (all varieties except Laredo and Otootan)
Squash
Tobacco
Tomato
Watermelon
Papaya

Weeds susceptible to root knot

Balloonvine
Clover, Mexican
Fennel, sweet
Maypop, or passionflower
Mayweed
Purslane

ANTHRACNOSE

Anthracnose, or pink boll rot, occurs in many of the cotton States. It is common in the mid-South, in the Southeastern States, and in many localities where cotton grows rank or where rainfall occurs at frequent intervals during the growing season. In some localities only a fraction of 1 percent of the crop is lost from this disease, while in others the losses may range from 40 to 60 percent.

SYMPTOMS

As the common name implies, anthracnose is primarily a disease of the bolls, but it may attack the leaves, stems, and bracts. It is also frequently responsible for poor stands, resulting from seedling infection and damping-off during cool, wet weather soon after planting. On the bolls the disease first appears as small, round, water-soaked spots, which later enlarge, become sunken, and finally develop reddish borders and characteristic pink centers (fig. 15). The pink centers of the spots are due to the spores of the fungus, which develop in abundance during periods of moist, cloudy weather. At other times the spores are scarce, and the diseased areas may have a grayish cast. The lint from infected bolls is often stained pink, is inferior in quality, and in many instances may be entirely rotted and worthless.

CAUSE

Cotton anthracnose is caused by a fungus (*Glomerella gossypii*) which lives over the winter on diseased bolls and stalks left in the field. It also overwinters in and on the seed from infected plants, and the planting of infected seed constitutes one of the principal means of spreading the disease.

CONTROL

Effective control of anthracnose is accomplished by selecting seed from disease-free plants, by using seed from areas with a minimum of infection, by using 3-year-old seed from slightly diseased fields, and by avoiding varieties that are known to be susceptible. The Half and Half and most Cook cottons are susceptible varieties.

Rotation of crops is also an important supplemental control measure. Since it has been shown that the fungus dies out in the seed after 12 to 14 months, the use of 2- and 3-year-old seed is a practical control measure, provided the land is free from infestation. With the necessary storage facilities to keep the seed dry and to avoid exposure to extremely low temperatures, the germination of 2- and 3-year-old cottonseed is not appreciably reduced.

BACTERIAL BLIGHT

Bacterial blight is variously called bacterial boll rot, angular leaf spot, vein blight, and black arm, depending upon the part of the plant attacked. It occurs generally throughout the South, and also in the southwestern cotton areas, especially in Arizona. This disease can be found every year in almost every cotton field, with damage ranging from a trace to as much as 40 to 60 percent. It is estimated

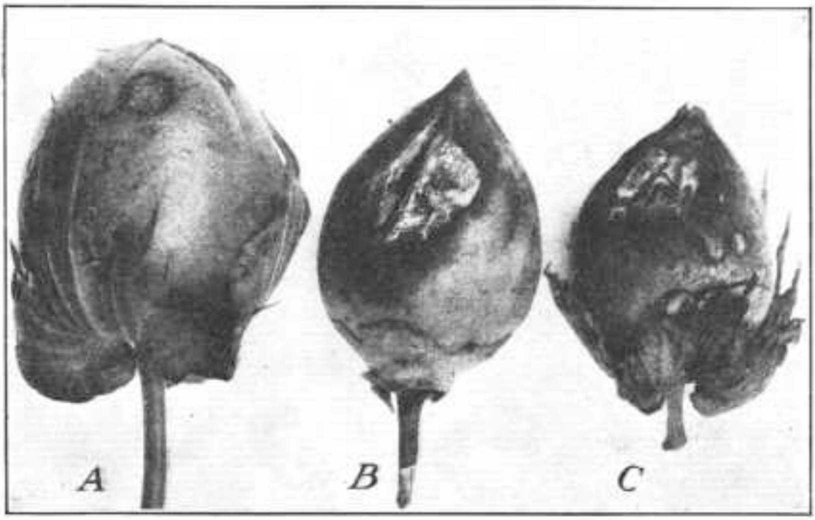

FIGURE 15.—Cotton bolls showing anthracnose or pink boll rot: *A*, Early stage; small water-soaked spot with pink center just appearing; *B* and *C*, bolls showing advanced stages with pink centers well developed.

that it causes an annual reduction in yield of upland cotton in the United States of 1 to 2 percent, and from 5 to 15 percent in severe outbreaks in Egyptian and sea island varieties. The latter are much more susceptible, and the damage is greater, owing to the more complete destruction of the bolls and branches. Defoliation, death of seedlings, and shedding and rotting of bolls are the destructive effects of bacterial blight in upland cotton. Damage is especially severe during cold, wet weather, the disease being spread chiefly by wind-blown rain. Dry, hot weather checks the infection, and in many localities cotton planted after the middle of May is seldom affected to any appreciable extent in the seedling stage.

SYMPTOMS

The first evidence of the disease is seen on the under surface of the cotyledons, young leaves, and stems, where round, green, water-

soaked spots of varying size, usually from one-eighth to one-fourth inch in diameter, occur within a week or 10 days after the seeds are planted. If the young leaves are held toward the light the spots appear translucent. Later the infection penetrates to the upper side of the leaves, forming elongated, angular, irregular areas between the veins. The infected areas of the leaves finally become dry and sunken and turn dark reddish brown to black, with the margins of the spots appearing rusty red to purplish (fig. 16). Frequently the disease extends along the veins of the leaf, producing a characteristic phase of the disease commonly called vein blight (fig. 17). This type of blight, although occurring in upland cotton, is more prevalent in sea island and Egyptian varieties, and in severe attacks it causes many of the leaves to turn yellow, curl up, and fall off.

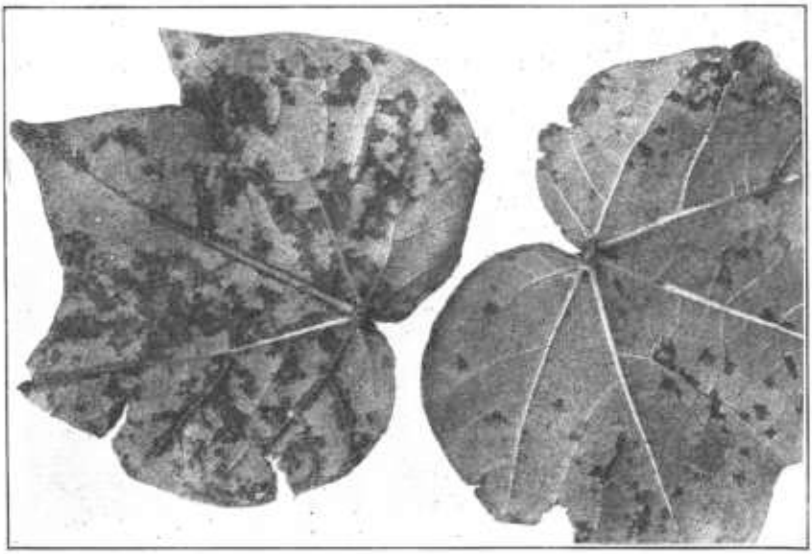

FIGURE 16.—Typical appearance of bacterial blight or angular leaf spot on upland cotton leaves. Note the water-soaked appearance and the distribution of the spots between and along the veins.

On the stems and branches the disease is commonly known as black arm, so called because the outer bark of the branches is killed and later turns black. This phase, although largely restricted to Egyptian and sea island cottons, is also frequently responsible for seedling injury and the death of young plants of upland cotton, especially in the black-land cotton sections of Texas, Arkansas, and Oklahoma. In these sections main stalks and branches of young plants often become infected and killed back for 3 or 4 inches (fig. 18), and the growth of the plants is thus retarded. A serious effect of the disease is that the tops and main stems of black arm-infected plants are easily broken by the wind. In many instances the infection may become so severe that the young plants are completely killed, and the resulting loss in such stands is so great that it is necessary to replant.

The disease is also frequently observed on the cotton flowers, especially following periods of rainy weather accompanied by wind-

storms and where insect visitation is in evidence. Under these conditions the disease may infect the petals, producing water-soaked, slimy areas usually extending to the base of the flower and infecting the young boll through the calyx, causing it to shed 2 or 3 days after the flower is dropped (fig. 19). The shedding of young bolls as a result of flower infection is one of the most serious aspects of blight and causes heavy losses in some localities. The disease also attacks mature or partially mature bolls. The first signs of the disease on the boll are small, water-soaked, dark-green, slightly raised, roundish spots, which gradually enlarge, turn black, and then shrink, as the tissues are killed (fig. 20). No grayish cast or pink color accompanies the spots caused by blight, as is the case with the anthracnose disease except when there is a subsequent infection with the anthracnose fungus. When bolls are attacked, several locks of the entire

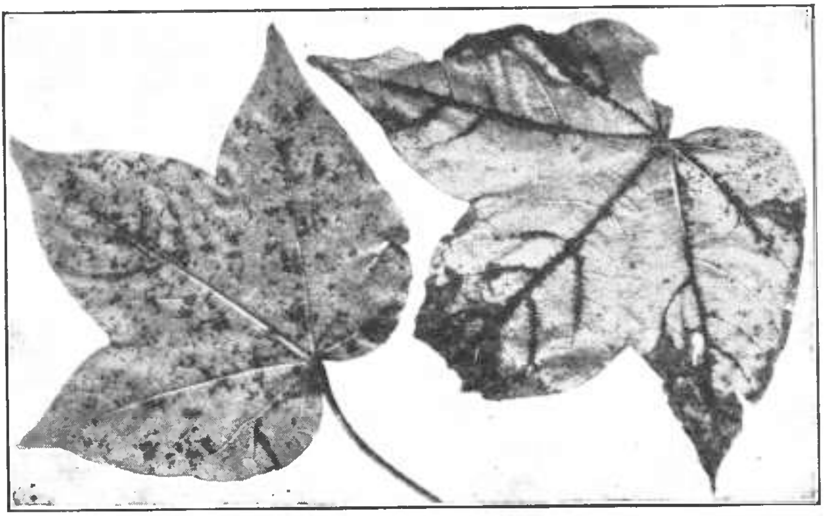

FIGURE 17.—Angular leaf spot and vein blight on leaves of sea island cotton. Both are caused by bacterial blight infection.

boll may be so injured that they fail to open. If the infected bolls do open, the lint is stained brown to black and is of a low grade.

The bacterial exudate acts like a glue in the bolls, and with small-boll varieties it is difficult to remove the partially diseased locks.

CAUSE

Bacterial blight is caused by a bacterium or germ (*Bacterium* (*Phytomonas*) *malvacearum*) which enters the leaves, stems, and bolls through the breathing pores and kills the adjoining cells, producing spots on the leaves, dead areas on the branches, and a decay of the bolls. Rainy weather accompanied by wind is an important factor in spreading the bacteria.

The bacteria causing the disease live over the winter chiefly on the seed and possibly on diseased portions of cotton stalks and bolls left in the field from the previous crop. There is very little evidence, however, that the bacteria survive in the soil. They are carried within the seed coat to a certain extent.

CONTROL

The most effective method of controlling blight is to use disease-free seed. The seed may be practically freed of the blight bacteria if treated with special dust disinfectants or if delinted with sulphuric acid or with hydrochloric acid gas.

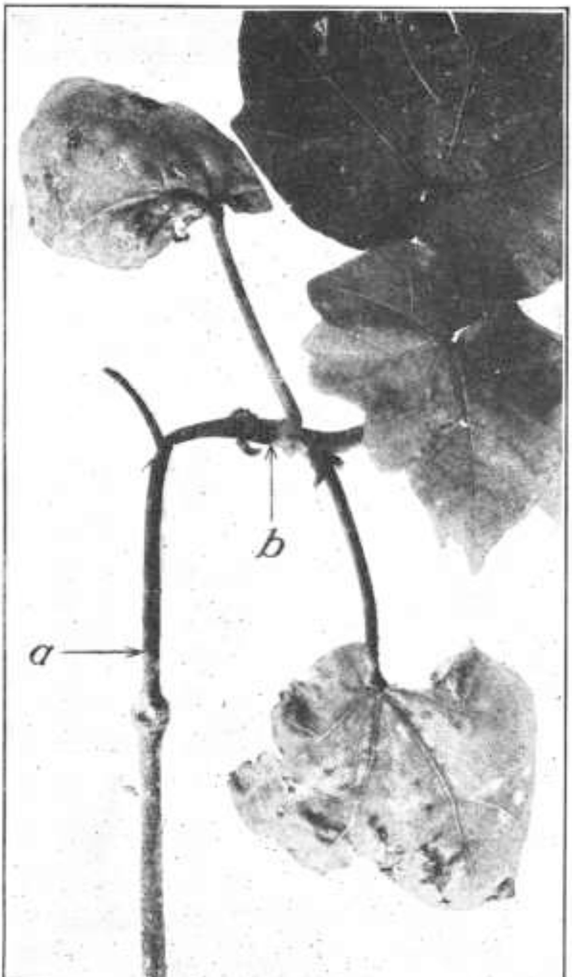

FIGURE 18.—A young cotton plant attacked by black arm (bacterial blight). Note the black diseased area on the stem between *a* and *b*. The infected stems or branches often break during windstorms.

The most effective dust disinfectants are some of the organic mercury compounds. Seed treated with these dusts at the rate of 4 ounces per bushel has given excellent stands of cotton with a minimum of blight-infected seedlings. The dust treatment is simple and inexpensive. The seed to be treated is placed in a closed drum, large cans, or wooden containers with the requisite amount of dust disinfectant and shaken vigorously for 15 to 20 minutes to insure a thorough coating of the dust on the seeds. The seed may then be planted immediately or kept in the containers for any length of time with no danger of injury from the treatment.

Experiments have shown that delinting cottonseed with sulphuric acid is quite effective in eliminating blight bacteria from the seed. Seed so treated, however, may give only fair to poor germination when cool or wet weather follows planting. Especially is this true where the crop is grown under irrigation. The method is also tedious, cumbersome, and dangerous for the grower to use and is not advised as a general farm practice, although it is used by breeders for special lots of seed stocks.[7]

[7] Persons especially interested may obtain further information on the use of this method by writing to the State experiment stations or to the U. S. Department of Agriculture.

Another method of delinting cottonseed for the control of blight and other diseases, developed in the Bureau of Plant Industry, is the hydrochloric acid gas process.[8]. This method requires special equipment for treating the seed. It has the advantage over the sulphuric-acid method in that the seed is kept dry throughout the treatment. The method is feasible, however, only on a commercial basis.

To be effective, treatment for blight control should include all seed used on the farm. Better still is a community program of seed treatment. If one grower practices seed treatment and the grower on an adjoining plantation does not, the blight bacteria may later be disseminated to the disease-free plants in fields where the seed was treated, produce infection, and reduce the benefits of treatment. A great benefit from seed treatment, however, comes in warding off infection in the seedling stages and insuring more uniform stands and more rapid growth as the season advances.

FIGURE 19.—Bacterial-blight infection at the base of a cotton flower (*a*), which later caused the young boll to shed.

RUST

Rust, also called black rust, yellow leaf blight, and potash hunger, is often seen on land of low fertility. This trouble occurs commonly in the Coastal Plain areas of the Cotton Belt, and while usually confined to the lighter soils, it is sometimes observed on the poorly drained, buckshot prairie, limestone sections of several States, especially in Alabama, Arkansas, Louisiana, and Mississippi. The disease varies in severity in different localities and even within the same field, the damage ranging from a trace in some fields to as much as 60 to 75 percent. The average loss for the entire Cotton Belt is estimated to be 4 or 5 percent.

[8] U. S. patent no. 1425688.

Cotton fields affected by rust usually do not produce plants with normal growth. The plants are small and lack a healthy green color. About the middle of the season the leaves assume a mottled appearance, yellow spots appearing over areas farthest removed from the

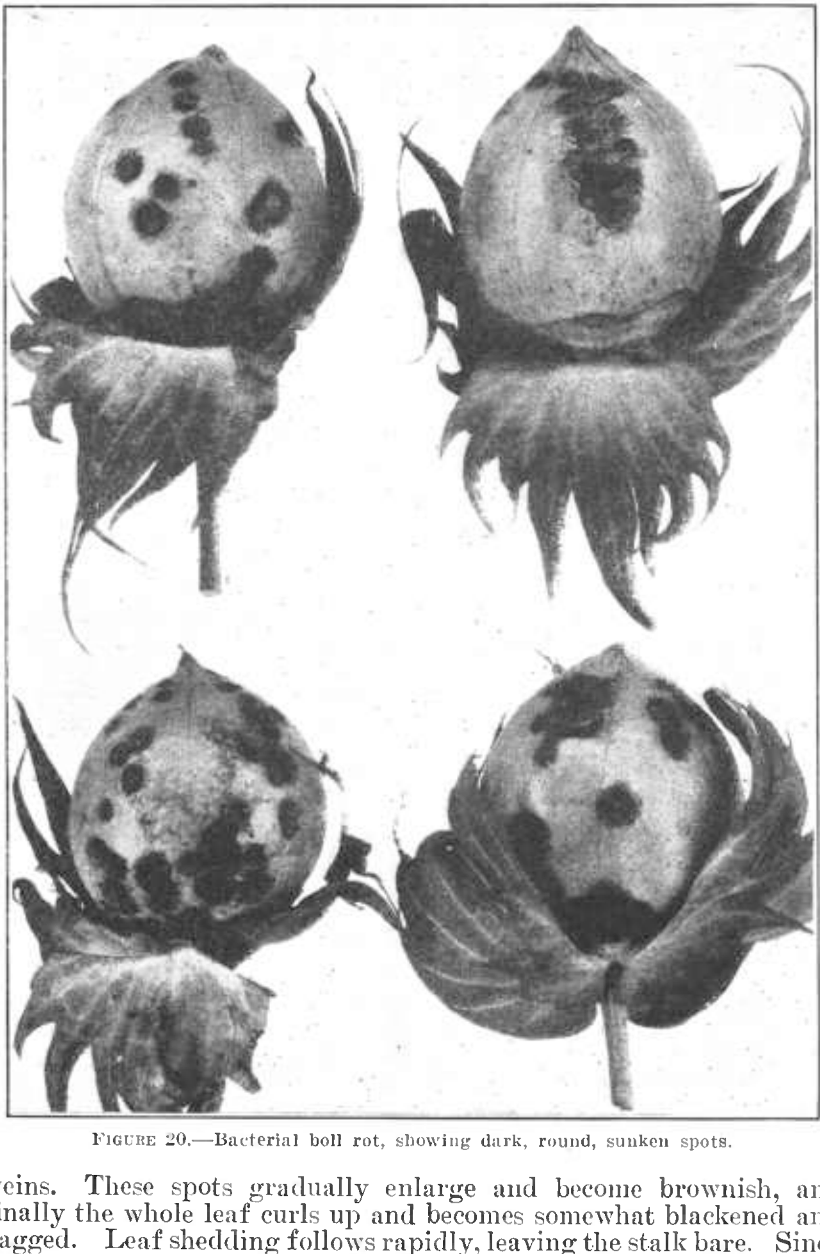

FIGURE 20.—Bacterial boll rot, showing dark, round, sunken spots.

veins. These spots gradually enlarge and become brownish, and finally the whole leaf curls up and becomes somewhat blackened and ragged. Leaf shedding follows rapidly, leaving the stalk bare. Since most of the leaves are shed prematurely, the bolls fail to develop properly, and the lint is of inferior quality.

Rust usually develops in definite spots (fig. 21) or in irregular areas in cotton fields, and, unless remedial measures are applied, it occurs year after year in the same places.

Many injuries that cotton planters ascribe to rust are caused by leaf mites, popularly known as red spiders. These mites attack and cause a reddening of a part or all of the leaf. In extreme cases defoliation of affected plants results. The mature red spiders or the yellowish younger ones, together with their fine webs, can usually be found on the under side of the discolored leaves, and thus the trouble can be distinguished from rust.

Rust is caused by soil conditions unfavorable for the proper growth and development of the cotton plant. It is not due to the attack of any disease-producing organism or to injury caused by insects, although the leaves of affected plants become weakened and later are usually attacked by a number of secondary organisms which hasten defoliation. Soil deficiencies largely responsible for rust are (1) lack of humus or vegetable matter in the soil, (2) lack of potash,

FIGURE 21.—Cotton rust as shown by irregular spots in the field, where but little cotton is produced.

and (3) improper drainage. Serious outbreaks of rust usually occur in fields with these deficiencies after prolonged periods of drought have been broken by heavy rainfall.

Rust is best controlled by building up soil fertility. Rotation, green-manure crops, such as rye, cowpeas, soybeans, Austrian peas, or vetch, together with barnyard manure, to increase soil vegetable matter, and the use of potash [9] or fertilizers containing potash (4 to 6 percent) will reduce rust damage on most soils.

CRAZY TOP (ACROMANIA)

A growth disorder of cotton plants, commonly called crazy top and also termed acromania, occurs in Arizona and California. The term "crazy top" describes the unusual abnormalities of branching and

[9] Fifty pounds of muriate of potash per acre or the equivalent from other potash sources should be used.

fruiting in the upper parts characteristic of the disorder. In certain seasons crazy top has caused serious financial losses on account of the sterility of many plants and resulting low yields. Both Egyptian and upland varieties are affected.

A striking feature of the disorder is the abnormal habit of branching. The fruiting branches in the upper portion of the plants are frequently replaced by vegetative branches, and the strong upright

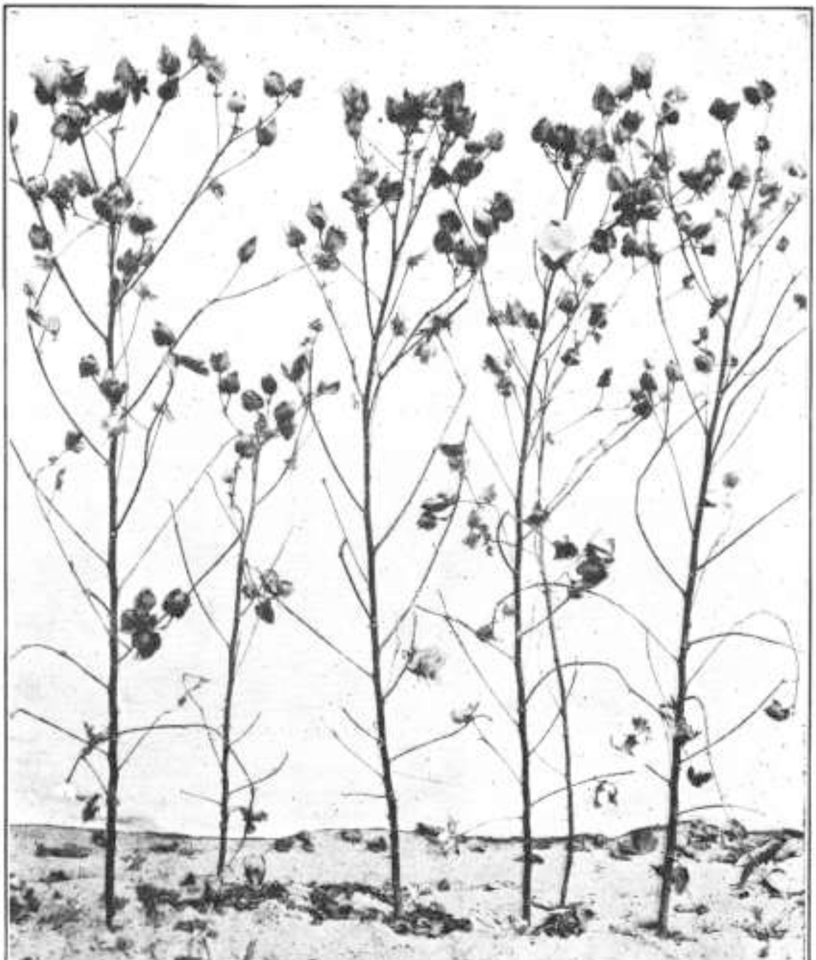

FIGURE 22.—Appearance of crazy top in Pima cotton plants late in the season with leaves removed to show the excessive top growth, stiff, erect branches, and the sterility of the lower fruiting branches.

growth of these in their abnormal positions is responsible in large part for the peculiar appearance of affected plants. One of the first symptoms is a general shedding of buds and young bolls. In some cases this may not begin until some of the lower branches and bolls have almost completed normal development. Late in the season many affected plants that are nearly sterile may set a late crop of bolls on the upper branches (fig. 22). The leaves may be rounded,

cupped, and thickened; the flowers small and likely to be imperfect, with stigmas depressed and anthers which fail to open or produce pollen. The bolls are likely to be small and malformed. But few seeds develop, and the lint is likely to be short and weak.

The actual cause of crazy top is not known, but it has been observed that severe crazy-top symptoms are associated with soil and cultural conditions that are unfavorable for the normal growth and development of the cotton plant. The more striking and injurious manifestations of crazy top are found in cemented soils, soils with impervious strata, and areas continuously cropped to cotton. The disease is rare in cotton grown on fine-textured alluvial soils or where cultural practices favorable for optimum growth have been regularly followed.

Cultural practices which tend to effect an even distribution of moisture and which deepen the root zone so that intermittent periods of stress and rapid growth are prevented during hot weather are effective in reducing crazy-top injuries. Rotation with alfalfa is one of several ways to meet this requirement.

MAGNESIUM DEFICIENCY

Magnesium deficiency in cotton occurs in many sections of the Cotton Belt, especially in the mid-Southern and Southeastern States. This deficiency is indicated by a purplish-red color of the leaves between the green veins. The lower leaves are first affected. Late in the season it is sometimes difficult to distinguish between the color due to magnesium deficiency and the color due to maturity of the leaf, although the color due to maturity is apt to be orange, whereas the color due to magnesium deficiency is purplish red.

Magnesium salts, such as magnesium sulphate, double sulphate of potash-magnesium in the fertilizer, or the addition of dolomitic limestone to the soil—broadcast at the rate of 1,500 pounds per acre—have been found to be effective in preventing magnesium deficiency.

SORE SHIN (DAMPING-OFF)

Sore shin or damping-off of cotton occurs widely wherever cotton is grown. It is perhaps more prevalent in heavy soils or those high in organic content, especially during cool wet weather when the land cannot be cultivated. It is primarily a disease of small seedlings, causing them to rot partly or completely, near the surface of the ground. It does not often cause serious damage in the principal sections of the Cotton Belt, though occasionally it reduces stands enough to require some replanting, particularly during unfavorable seasons in the Southwestern States, where the night temperatures during the spring are unusually low.

Cotton seedlings infected with sore shin first show dark to reddish-brown sunken cankers on the stems near or below the soil line (fig. 23). In severe outbreaks the cankers may encircle the stem and penetrate so deeply that the plants fall over and die. Frequently, however, on the return of warm, favorable weather many plants recover and outgrow the injury, unless they are so seriously injured that the normal functioning of the root system is destroyed.

Sore shin is caused by a fungus (*Corticium vagum*), which seems to be present everywhere in the soil but which attacks the cotton plant only under conditions particularly favorable to the fungus and unfavorable to the plant (cold, moist weather).

No very satisfactory control methods are known. The best practice is to fertilize the plants liberally so as to give them a vigorous start. Owing to the habits of growth of the fungus in the soil, crowding of plants in the hills of the rows after thinning should be avoided.

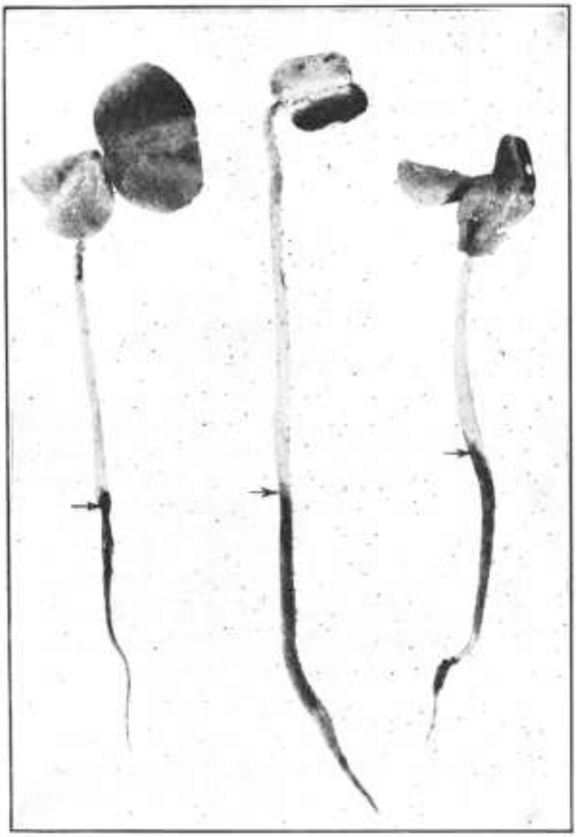

FIGURE 23.—Cotton seedlings infected with the sore-shin fungus. Dark reddish-brown sunken cankers are seen at points indicated by arrows.

It usually happens that where one seedling in a cluster becomes infected the other plants in the group are almost sure to contract the disease, and there is a greater likelihood that the entire hill of plants will be destroyed than that a portion of them will survive. Where sore shin is a factor in reducing stands, planting the cotton in drills is preferable to planting in hills. This method also gives greater chance of better spacing from surviving plants than does the hill system.

ASCOCHYTA BLIGHT

Ascochyta blight is a relatively new disease of cotton, first reported in this country in northwestern Arkansas in 1920. Since its first discovery the disease has been found in South Carolina, Virginia, North Carolina, Alabama, and Mississippi. In some fields 50 percent of the plants have been affected. In severe cases plants are completely defoliated.

Rather large rounded to irregular spots are formed on the leaves. These enlarge rapidly in humid weather and present at first a slightly grayish water-soaked appearance, later turning light brown or tan with a reddish-brown border.

On the bolls and stems the spots are usually similar in appearance to those on the leaves but are darker in color. Stem infections are generally most conspicuous and occur most often at the bases of the

leaf petioles. The spots, at first dark brown, enlarge rapidly and become sunken and light brown in the center. They advance up and down the stem much more rapidly than around it. The bases of the leaf petioles are soon surrounded, the leaves droop and die, and the stem itself is soon encircled, whereupon the parts above die and dry up. Early decay and the falling out of the centers of diseased stem spots are characteristic. The boll spots are similar to the stem spots except that the centers are darker. When the fungus is advancing very rapidly a dark-green water-soaked area surrounds the brown portion of the spot. Dry weather may check the external advance of the fungus, but the boll continues to rot internally.

Ascochyta blight is caused by a fungus (*Ascochyta gossypii*) which attacks all parts of the plant aboveground. The fungus is able to infect leaves, stems, and bolls without any apparent previous wounding of the tissues. In practically every instance serious outbreaks have occurred early in the season during periods of excessive rainfall and high humidity. The occurrence of dry and warmer weather results in checking the disease and its final disappearance and the recuperation of all plants not too severely injured. In most cases, except where plants are killed outright, they recover sufficiently to produce a fair crop. The resulting loss, therefore, is generally less than might be estimated at the time the disease is active.

The disease is new, and little work has been done on control methods. It has been proved, however, that the causal fungus can live over winter on dead, diseased stalks in the field and infect cotton the following spring. Crop rotation is suggested as the most evident remedy at the present time.

LIGHTNING INJURY

Lightning injury to cotton, while not a disease, is a common cause of dead spots in cotton fields and warrants brief mention. These spots, usually seen after midseason, are roughly circular in shape (fig. 24, *B*) and vary in diameter from 1 to 3 or more rods. In the center the plants are usually all killed, and the leaves and stems soon turn black, the leaves clinging to the plants for some time (fig. 24, *A*). Between these dead plants in the central area and the surrounding uninjured field there is usually a zone of plants showing diminishing degrees of injury. Some of these plants live for several days, their leaves meanwhile becoming yellow, then brick red, and the plants finally turning black and dying. Others, though injured, live through the season and produce a partial crop.

MINOR DISEASES

In addition to the major cotton diseases already discussed, there are a number of diseases of lesser importance. Several of these occur regularly every season, while a few are encountered only occasionally in localized areas. They cause a certain amount of damage that is difficult to estimate. Only the more important will be mentioned.

LEAF DISEASES

Leaf blight is caused by a fungus (*Alternaria* sp.) which produces an abundance of papery, rusty-brown spots of irregular shape which

vary in size from one-eighth to one-half inch in diameter. As these spots enlarge they form a series of concentric markings that are quite prevalent on the leaves during the latter part of the season (fig. 25).

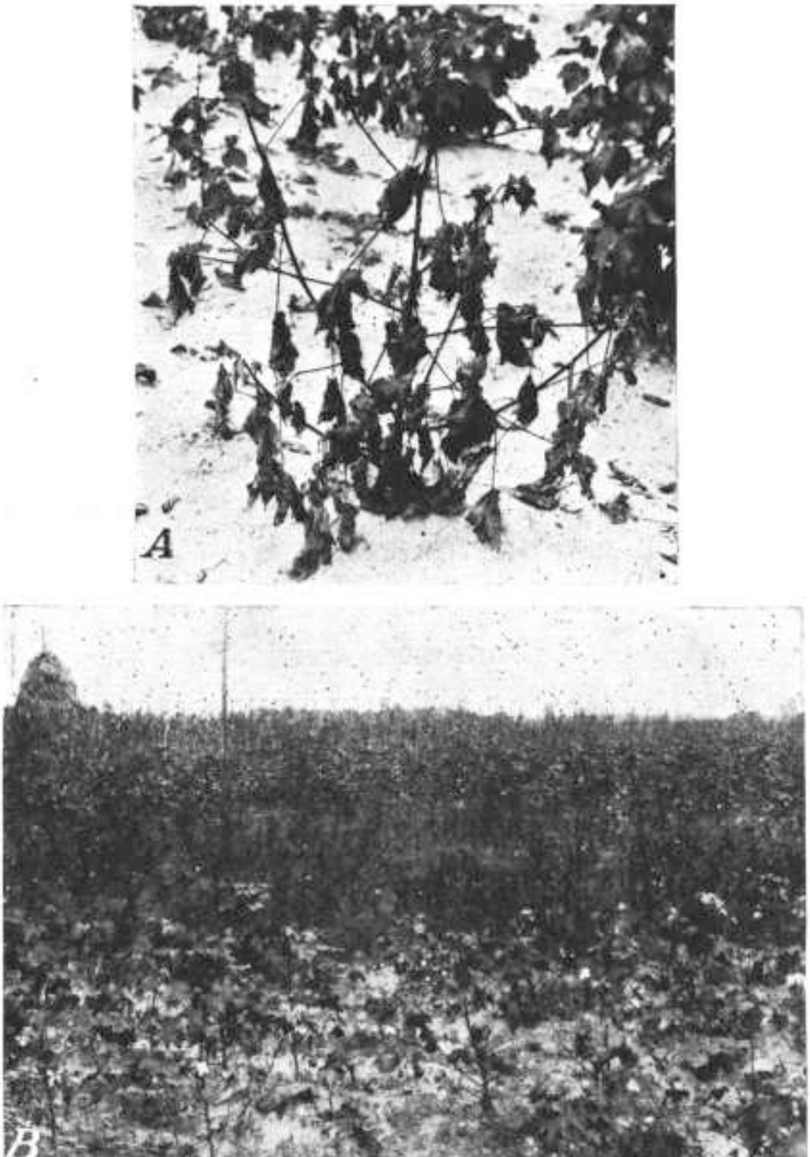

FIGURE 24.—*A*, Cotton plant killed by lightning; leaves and bolls still clinging to the branches; *B*, lightning injury in cotton field showing circular areas, about in the middle of the photograph, where plants were killed by lightning and weeds have grown.

This disease appears in many cases to be associated with potash hunger or rust injury and often causes severe defoliation. It also follows injuries caused by angular leaf spot and red spiders.

Leaf spot, due to the attacks of the *Cercospora* fungus (*C. gossypinæ*), is extremely common in almost every cotton field toward the end of the season. The spots caused by *Cercospora* are usually small, rarely more than one-fourth of an inch in diameter, and are roundish to irregular in shape. Distinctive features are purple borders and white centers. After reaching maximum size the centers of the spots often fall out, producing a shot-hole effect. This fungus may attack uninjured tissues, but it seldom causes as much defoliation as the alternaria leaf blight.

Frosty blight, also called areolate mildew, occurs on the leaves of plants growing in damp places, especially toward the end of the season. The spots are small, angular in shape, and are typically

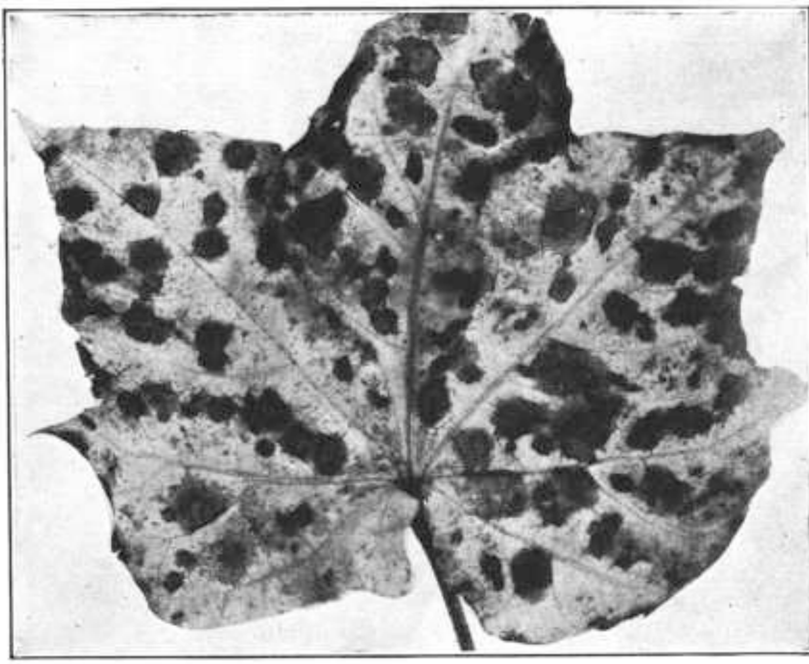

FIGURE 25.—A cotton leaf infected with the leaf-blight fungus. Note concentric rings in the larger spots.

white on the under side of the leaves (fig. 26), owing to the presence of fruiting bodies of the causal fungus (*Ramularia areola*). The disease, although conspicuous, causes little damage.

The true rust of cotton is caused by one or the other of two fungi. One rust (*Kuehneola gossypii*) is characterized by the presence on the leaves of numerous slightly raised, rusty brown, circular spots about the size of a pinhead. This disease occurs in Cuba and Puerto Rico and has been reported once from Florida. The other rust, *Puccinia hibisciata* (*Aecidium gossypii*), causes larger raised orange-colored spots on the leaves, bolls, and involucral bracts, and occurs to a limited extent in Texas, Arizona, New Mexico, and southern California. Both are distinctly different from the disease commonly called rust, previously described (p. 23).

BOLL DISEASES (ROTS)

Diplodia boll rot is often destructive during wet seasons in the Mississippi Valley, particularly in Louisiana and Mississippi. In Louisiana damage sometimes reaches 10 percent, and the loss in that State averages about 2 percent. This boll rot, although present in the southeastern cotton States, is not so destructive there. It is caused by a fungus (*Diplodia gossypina*) which usually attacks the bolls from the stem end and gains entrance into the tissues through weevil or other punctures or through injuries resulting from other diseases. After entering, the fungus develops rapidly and quickly destroys the boll. When the boll has rotted tiny blisters appear on its surface,

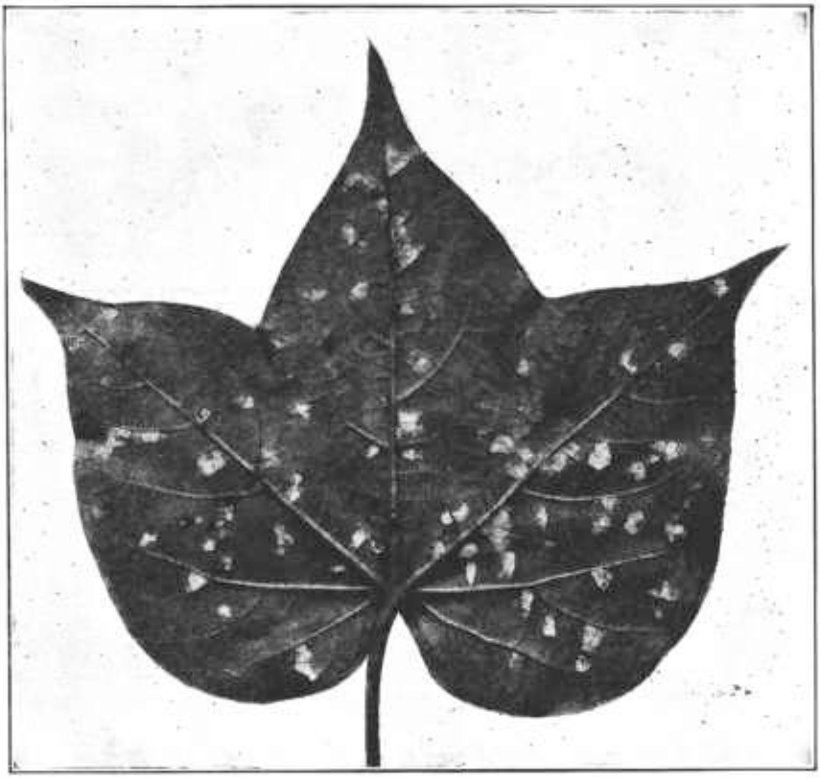

FIGURE 26.—Under side of a cotton leaf attacked by areolate mildew, or frosty blight.

and from these, black sooty masses of spores are released and cover the whole surface of the boll. They are then scattered to other bolls that may be punctured or otherwise injured and new infections result. The lint from diplodia-rotted bolls is usually matted, smutty, and worthless. As a rule this boll rot causes greater damage to the lower bolls in contact with the soil, and damage is greater in the lower fertile areas in fields, where rank vegetative growth occurs. The disease is not seed-borne. Rotation of crops and thorough weevil control are suggested as control measures.

Other common boll rots are those produced by species of *Fusarium* (chiefly *Fusarium roseum* and *F. moniliforme*). One produces a

pink rot of both the boll and the lint. Light pink masses of spores occur on the surface of the rotting bolls. This differs from the anthracnose rot in that the spore masses are not slimy or confined to the center of the spots. The spores are produced as powdery masses over the entire diseased portions of the boll and are a lighter pink than the anthracnose spores. The fungus lives over in the field as well as on the seed and lint and may produce spots on the young seedlings in the spring.

Two boll rots, which frequently occur in many sections of the Cotton Belt, are caused by the mold fungi *Aspergillus niger* and *Rhizopus nigricans.* Both are largely wound parasites and are frequently referred to as smut of bolls, especially in their later stages. The aspergillus rot occurs especially in the Southwest.

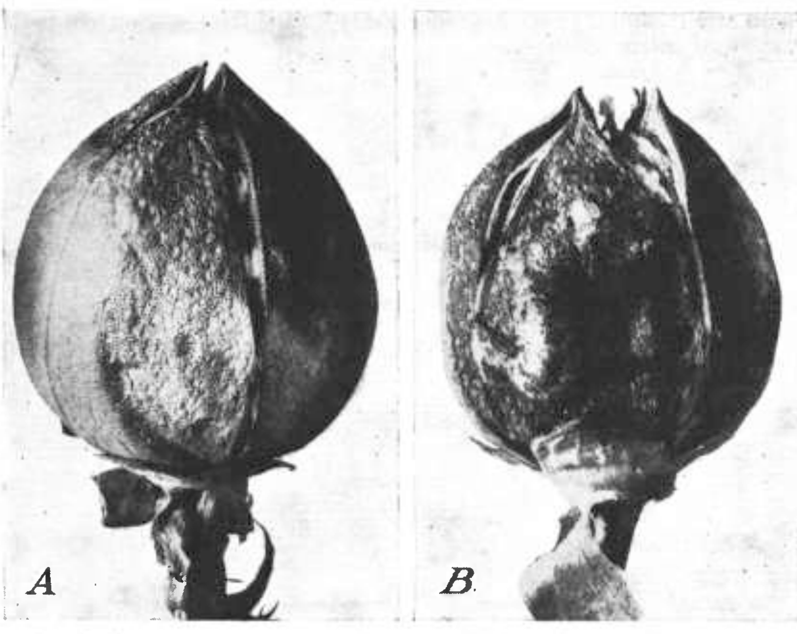

FIGURE 27.—Cotton boll rot caused by *Aspergillus* (*A*) and *Rhizopus* (*B*).

The typical symptoms of the aspergillus decay follow: The rot begins as a soft, pinkish spot either on the side of the boll or somewhere near its base. The hue and the extent of the pink discolorations vary more or less, but the discoloration is always present and is characteristic of this sort of decay. As the lesion varies in size, the color of the older decayed area turns from pink to brown (fig. 27, *A*) and the original discoloration remains only in the freshly decaying regions; that is, on the border of healthy and diseased tissues. If such a boll is cut open through the affected area the same pink to purplish and red-brown shades of the invaded tissues will be seen. The fungus may destroy all parts of the boll, including the seed and the lint. It produces an abundance of spores in the affected area, which soon becomes dark and gives the bolls a smutty appearance. If the entire boll is rotted it dries up and

remains closed, but if the progress of the disease is checked for some reason or other the bolls may open partially.

The rhizopus rot lacks entirely the pink discoloration characteristic of the aspergillus decay. The affected portions of the boll are olive-green in color and retain this uniform discoloration until the decayed parts dry up, at which time they become darker (fig. 27, *B*). The spore masses are not quite so dense as those produced by the *Aspergillus* and form a dark-gray or blue-gray rather than a sooty black powdery film over the boll.

Infection of the boll by either of the above-mentioned two fungi depends on injuries caused by insects, the most noticeable of which are those caused by the bollworm and the bollweevil. Cases have also been observed in which these two boll rots have followed injuries made by anthracnose and bacterial boll rot. Therefore, reduction in the damage that they indirectly cause depends on control of insects and other diseases.

U. S. GOVERNMENT PRINTING OFFICE: 1935

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